Chapter 7

COMPETITIVENESS

This chapter presents module descriptions for the competitiveness component of a CTSA, including the following modules:

- Regulatory Status.
- Performance Assessment.
- Cost Analysis.

Each of these modules provides information on basic issues traditionally important to the competitiveness of a business: its need or ability to comply with environmental regulations; the performance characteristics of its products relative to industry standards; and the direct and indirect costs of manufacturing its products. A CTSA weighs these traditional competitiveness issues against a new generation of competitiveness issues: the health and environmental impacts of alternative products, processes, and technologies.

Data from all three of these modules are considered in the Social Benefits/Costs Assessment and Decision Information Summary modules along with risk data, conservation issues, and other information. In addition, the Regulatory Status and Performance Assessment modules transfer data to other modules of a CTSA. For example, the Regulatory Status module determines if control technologies are required for a particular alternative and transfers that information to the Control Technologies Assessment module.

The Performance Assessment module is one of the most important data gathering modules of a CTSA. A DfE project team typically conducts a performance demonstration project during this module where performance data are collected together with data on capital, operating, and maintenance costs; energy and other resource consumption rates; waste generation rates; and worker exposure (particularly for new or novel alternatives not evaluated in the Workplace Practices & Source Release Assessment module). These data are then transferred to the appropriate modules. For example, cost data from the Performance Assessment module can be used to perform a comparative cost analysis of alternatives in the Cost Analysis module.

REGULATORY STATUS

OVERVIEW: The Regulatory Status module determines the statutes and regulations that govern the chemicals and industrial processes in the use cluster. Although federal environmental regulations are typically assessed in a CTSA, this module also provides guidance in conducting searches of other Federal regulations and state and local regulations that may be pertinent to the use cluster being assessed or the group performing the evaluation.

GOALS:

- Determine the pertinent laws and regulations, including those governing use and release to the workplace or environment, affecting the chemicals, processes, and technologies in the use cluster or the use cluster industry.

- Assist in the evaluation of economic and social costs and benefits of the use of a particular chemical, process, or technology by determining the regulatory requirements that lead to costs of compliance (such as treatment costs, permit costs, and reporting costs) and public disclosure of environmental information, possibly affecting public relations.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Ability to identify laws and regulations affecting the chemicals and technologies in the use cluster or the target industry, including environmental, consumer product safety, and occupational safety and health laws and regulations.

- Ability to do legal research and search legal data bases.

- Legal expertise required to interpret laws and regulations and their application in a particular jurisdiction or particular situation.

Within a business or DFE project team the people who might supply these skills include environmental compliance managers and corporate attorneys, particularly those specializing in environmental compliance. Environmental consultants and law firms can also provide the skills and knowledge necessary.

DEFINITION OF TERMS:

<u>*Code of Federal Regulations (CFR)*</u>: The official codification of federal regulations that were originally published in the daily *Federal Register*. *Citation note:* In a citation to the CFR (e.g.,

40 CFR 129), the first number is the number of the title on a particular topic (Title 40 covers "Protection of Environment"), and the second number indicates the "part" or the section number (part 129 regulates "Toxic Pollutant Effluent Standards"). *Updating:* If the CFR part or section has been repealed or amended, the List of CFR Sections Affected (LSA) will provide a citation for the current material in the *Federal Register*.

Federal Register (Fed. Reg.): A daily publication of proposed and final federal regulations. *Citation note:* In a citation to the *Fed. Reg*., the first number indicates the volume and the second number indicates the page. A complete citation also includes the date of publication. For example, 60 *Fed. Reg*. 5320 (Jan. 27, 1995) is Volume 60, page 5320, published on January 27, 1995.

Regulation: A rule or order having the force of law issued by the executive branch of government (e.g., by a federal administrative agency) to implement a statute.

Statute: A law enacted by the legislative department of government, whether federal, state, city, or county.

United States Code (U.S.C.): The official text of federal statutes. *Citation note:* In a citation to the Code (e.g., 49 U.S.C. 1261), the first number is the number of the title for a particular topic (Title 49 covers "Transportation"), and the second number is the section number of the statute. The United States Code Annotated (U.S.C.A.) and the United States Code Service (U.S.C.S.) follow the same numbering system and include annotations to federal regulations implementing the particular Code section. *Updating:* All of these texts are updated regularly by pocket parts at the end of each volume and/or supplementary volumes.

APPROACH/METHODOLOGY: The following presents a summary of the approach or methodology for identifying regulations affecting substitute chemicals, processes, or technologies. Further methodology details for Steps 2, 3, and 4 follow this Section.

Step 1: Obtain chemical identities including CAS RNs and synonyms from the Chemical Properties module. Identify the industry sector and specific process type (e.g., printing - lithographic) from the Chemistry of Use & Process Description module.

Step 2: Search secondary materials to preliminarily determine the statutes and regulations that apply to a particular chemical, process, or technology.

Step 3: Review federal statutes by reviewing codifications (e.g., *United States Code*) or looseleaf services (e.g., *Environment Reporter*).

Step 4: Review the federal regulations by original publication, codification, looseleaf service, or computer data base.

Step 5: Search case law for court interpretations of federal statues and regulations. In order to perform a thorough and comprehensive regulatory analysis, if time and resources permit, an environmental attorney, qualified law student, or paralegal should conduct an up-to-date search of case law from the federal courts to determine if there have been any court interpretations of statutes and regulations applicable to the chemical, process, or technology, and to determine the status of challenged regulations. Official case reporters can be used, such as *U.S. Reports*, or unofficial reporters, such as *United States Law Week*, *Supreme Court Reports*, *Federal Reporter*, and *Federal Supplements*. Other sources include *Environment Reporter Cases* and WESTLAW® or LEXIS® computer data bases.

Step 6: Review state statutes, regulations, and case law. Most states are administering federal environmental and occupational health and safety regulatory programs with federal approval and may have stricter and/or different requirements than federal statutes and regulations. Therefore, for a specific facility location it may be desirable to research state law as part of the regulatory analysis. In addition to official codifications of the state statues and regulations that may be available in a major law library, the *Environment Reporter* is a valuable resource for locating state environmental statutes and regulations. For completeness, state court decisions should also be reviewed for interpretations of state statutes and regulations. State statutes and case law can also be searched using WESTLAW® or LEXIS® computer data bases.

Step 7: Review local statutes and regulations. In some states, local governments also administer environmental statutes and regulations and may have different and stricter requirements than federal and state statutes and regulations. For a specific location, it may be desirable to review these local requirements, which can be obtained by consulting the local government, by visiting a local law library, or by consulting a local industrial development office which may have special packets concerning local regulations. For completeness, state court decisions should be reviewed for interpretation of local statutes and regulations.

Step 8: Provide the results of the search to the Risk, Competitiveness & Conservation Data Summary module. If a control technology would be required for one of the substitute chemicals in the application being evaluated, provide these requirements to the Control Technologies Assessment module. Additional regulatory information, such as specific disposal requirements, should be provided to the Regulatory Status module. If a chemical is planned for a ban or phase-out, provide this information to the Market Information module.

METHODOLOGY DETAILS: This section presents methodology details for completing Steps 2, 3, and 4. If necessary, additional information on these and other steps can be found in the published guidance.

Details: Step 2, Searching Secondary Sources

There are several commercial sources that can be used to preliminarily determine the statutes and regulations that apply to a particular chemical. *These sources will provide only a brief summary of the major regulations governing a chemical, however. They are not official sources and are not updated as often as the federal regulations. Even sources that are updated frequently (e.g., by supplements or a looseleaf service) cannot be relied upon as authoritative law.*

Examples of secondary sources include:

- EPA *Registry of Lists*: A data base of federal regulations applicable to specific chemicals that can be searched by chemical. It is maintained and updated by EPA for its own use and is not generally available to the public.
- The *Suspect Chemicals Sourcebook*: This reference shows what regulations apply to any given chemical. It directs the researcher to a Source List (e.g., Clean Water Act Section 311) which provides capsule descriptions of each chemical and complete chemical listings for each regulation. In many cases, the original regulation is reprinted (e.g., from the *Code of Federal Regulations* or the *Federal Register*).
- *Law of Chemical Regulation and Hazardous Waste*: This source is a legal treatise with an update service that keeps it fairly current. It analyzes not only environmental laws, but also occupational safety and health regulations, food additive regulations, and consumer product regulations with footnotes to key statutory and regulatory texts. Since it is not organized by chemical name, there is no simple way to find all the regulations governing a particular chemical. The treatise is organized by broader topic, such as "Regulation of the Generation, Transportation, Storage, and Disposal of Hazardous Waste."
- Regulatory Profiles: Profiles developed by EPA listing pertinent environmental regulations affecting specific industries. See the section on data sources for examples of EPA regulatory profiles that are currently available.
- Topical Material: Treatises and looseleaf services exist for specific federal statutes. See the section on data sources for some examples of guides to the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Toxic Substances Control Act (TSCA). These can be searched for applicability to the chemicals of interest.

Details: Steps 3 and 4, Searching Federal Statutes and Regulations

<u>Identifying Applicable Statutes and Regulations</u>

Federal statutes that may apply include laws governing releases of pollutants to air, land, or water, as well as laws governing the shipment of hazardous materials, the safety of consumer products containing hazardous chemical ingredients, and the exposure of workers to chemicals in the workplace. The discussion that follows identifies some of the key provisions of several federal statutes. It does not attempt an in-depth analysis nor does it list all the provisions that may apply.

The Clean Air Act (CAA) (42 U.S.C. 7401-7671q): Governs emissions of air pollutants to the environment. In addition to the *Code of Federal Regulations*, federal air regulations can be located easily in the *Environment Reporter (ER) Federal Regulations Binders*. Examples of key provisions include:

- National Ambient Air Quality Standards (NAAQS): EPA has established NAAQS for six criteria pollutants:
  (1) Sulfur dioxide (SO_2).
  (2) Nitrogen dioxide (NO_2).
  (3) Carbon monoxide (CO).
  (4) Ozone.
  (5) Lead.
  (6) Particulate matter (PM-10).
- Hazardous Air Pollutants (HAPs): The National Emissions Standards for Hazardous Air Pollutants (NESHAPs) control 189 pollutants listed at 42 U.S.C. 7412. The regulatory standards for these substances are spelled out at 40 CFR 61. Sources must also prepare and implement risk management plans with the Chemical Safety and Hazard Investigation Board.
- State Implementation Plans (SIPs): The states are authorized to establish programs for implementing the CAA. Regulations for each SIP can be found at 40 CFR 52. These can also be found in the *ER Federal Regulations Binder* at Tab 125.
- Chlorofluorocarbons (CFCs) or halons will be phased-out under Title VI of the CAA Amendments, at 42 U.S.C. 7671.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601-9675): Governs the cleanup of sites where hazardous substances have been released or disposed. Examples of key provisions include:

- A list of "hazardous substances" (see 42 U.S.C. 9601 for definition; see 40 CFR 302.4 for list of chemicals).
- Reportable Quantity (RQ) for releases of chemicals (see 40 CFR 302.4). If there is a release of the substance greater than the RQ, any person in charge of the facility must notify the National Response Center.

T**he Clean Water Act (CWA)** (33 U.S.C. 1251-1387): Governs the discharge of pollutants to United States waters, but does not cover ground water. Federal water pollution regulations can be found in the *ER Federal Regulations Binder* and the *Code of Federal Regulations*. Examples of key provisions include:

- The National Pollutant Discharge Elimination System (NPDES). NPDES permits are needed for point source discharges into surface waters (see 33 U.S.C. 1342 & 40 CFR 122.2). Permits include limits on discharge of specific chemicals as required by regulations for specific industry categories.
- "Priority pollutants" are listed at 40 CFR 122, Appendix D.
- National effluent standards source categories. The CWA has a system of minimum national effluent standards for several industry categories (see 33 U.S.C. 1316 for the categories and 40 CFR 400-460 for effluent guidelines and standards; toxic pollutants regulated under these standards are found at 40 CFR 401.15).

The Emergency Planning and Community Right-To-Know Act (EPCRA) (42 U.S.C. 11001-11050; also known as Superfund Amendments and Reauthorization Act [SARA] Title III): Requires reporting to EPA for toxic chemical releases to the environment and off-site transfer of chemicals. Reports are publicly available. Facilities must file an annual Toxic Release Inventory for each chemical listed at 40 CFR 372.65 if the facility has more than 10 employees and manufactures, processes, or otherwise uses amounts of chemicals in excess of the threshold reporting amount (see 40 CFR 372.25).

The Federal Food, Drug, and Cosmetic Act (FFDCA) (21 U.S.C. 301-395): Governs chemicals used as food additives or in cosmetics.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
(7 U.S.C. 136-136y): Governs chemicals used as active ingredients in pesticides.

The Hazardous Materials Transportation Act (HMTA) (49 U.S.C. 1801-1812): Governs shipments of hazardous materials in commerce by road, air, rail, and water. Examples of key provisions include:

- The listing of materials that are hazardous to transport in the Hazardous Materials Table (49 CFR 172.101), which also contains regulations for packaging, labeling, and transportation.

The Consumer Product Safety Act (CPSA) (15 U.S.C. 2051-2084) and **The Hazardous Substances Act (HSA)** (15 U.S.C. 1261-1277): Governs the safety of consumer products, including hazardous chemical ingredients. "Hazardous substances" defined by 15 U.S.C. 1261(f)(1)(A) or by any regulation issued by the Consumer Product Safety Commission are subject to labeling requirements, and the Commission may ban a product through regulation.

The Occupational Safety & Health Act (OSHA) (29 U.S.C. 651-678): Governs the exposure of workers to chemicals in the workplace. Examples of key provisions include:

- The Hazard Communication Standard, explained in 29 CFR 1910.1200, mandates notice requirements, labeling requirements, and the availability of Material Safety Data Sheets (MSDSs). Requires employers to inform and train employees about hazardous chemicals.
- Hazardous air contaminants in the workplace are controlled by Permissible Exposure Limits (PELs). These are found in 29 CFR 1910.1000 Table Z-1-A.

The Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901- 6991): Governs the generation, transport, treatment, storage and disposal of hazardous chemical waste. In addition to the *Code of Federal Regulations*, the *ER Federal Regulations Binder* is a good resource to locate regulations on hazardous waste. Key provisions include:

- Definition of hazardous waste:
  Solid waste as defined by RCRA that fits any category below is hazardous waste subject to RCRA regulation:

- Listed wastes (see 40 CFR 261 - four lists).
- Characteristic wastes (e.g., ignitable, corrosive, reactive, or toxic wastes. See 40 CFR 261.2).
- Substances derived from listed wastes.
- Substances mixed with either listed or characteristic wastes.

■ Treatment, Storage, and Disposal Facility (TSDF) regulations: Permitting requirements are found at 40 CFR 264-265, 270).

The Toxic Substances Control Act (TSCA) (15 U.S.C. 2601-2692): Governs manufacturing, use, and disposal of toxic chemicals; requires premanufacturing notices for new chemicals, and comprehensive reporting for certain existing chemicals. In addition to the *Code of Federal Regulations,* the *ER Federal Regulations Binder* is a good resource to locate TSCA regulations. TSCA regulates "chemical substances and mixtures" as defined in the act and regulations (40 CFR 710). Substances regulated under FIFRA and FFDCA are exempt.

Codifications of Federal Statutes

Codifications of federal statutes include:

■ *United States Code* (U.S.C.).
■ *United States Code Annotated* (U.S.C.A.).
■ *United States Code Service* (U.S.C.S.).

Other publications which are useful tools for locating the text of environmental statutes include:

■ *Environmental Law Reporter Statutes Binder.*
■ *ER Federal Laws Binder* (published by the Bureau of National Affairs [BNA]).

These publications do not contain other federal laws, such as the Occupational Safety and Health Act (OSHA), which may apply to the chemical being researched. Other looseleaf services specialize in a particular area, such as:

■ *Chemical Regulations Reporter* (published by BNA).
■ *Occupational Safety and Health Reporter* (published by BNA).
■ *Food and Drug Law Reporter* (several publishers).

Locating Federal Regulations

Sources that can be used to access the regulations in text form include:

■ Annotations to the U.S.C.A. or U.S.C.S., which cite regulations that implement particular statutory provisions.
■ Index to the *Code of Federal Regulations*.
■ *ER Federal Regulations Binder*.
■ *Federal Register* where the regulation was originally published (also contains explanatory materials not codified in the CFR).
■ Computer data bases.

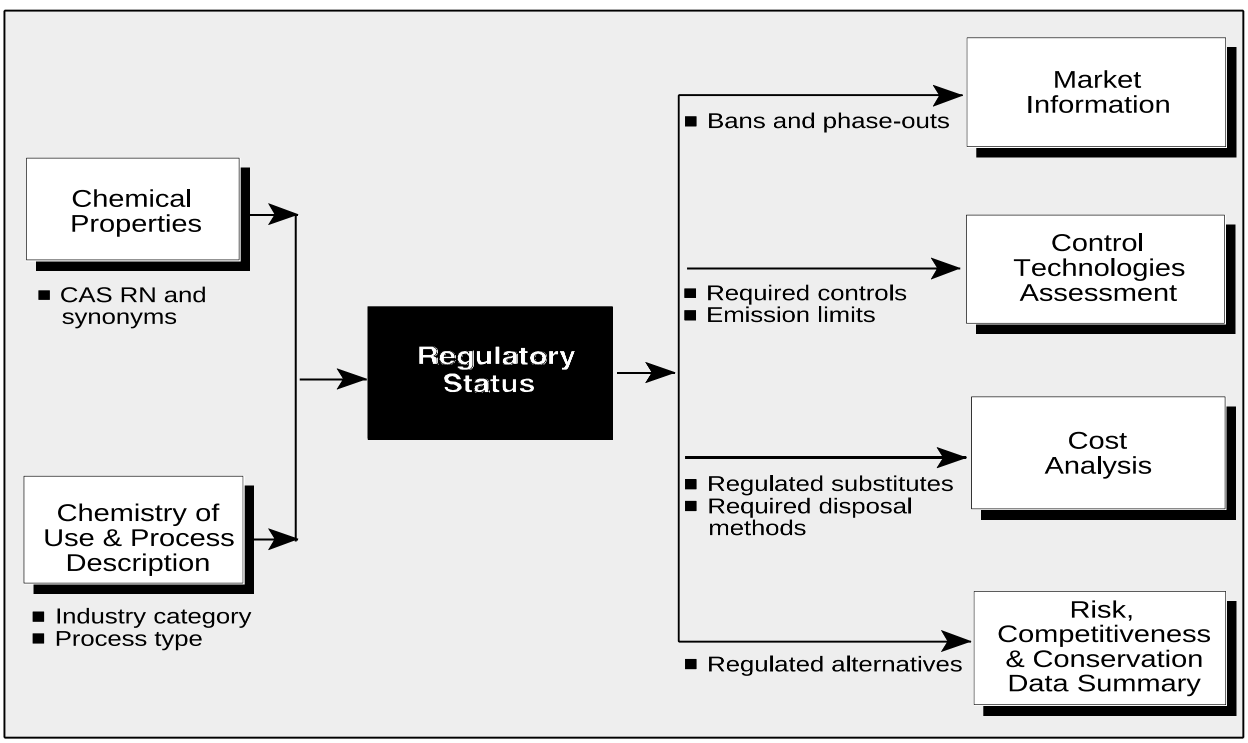
Searching Computer Data Bases

The WESTLAW® network has data bases for both the *Code of Federal Regulations* (FENV-CFR) and the *Federal Register* (FENV-FR). Within these data bases, it is possible to search by chemical name (e.g.,"benzene"). However, the search may produce hundreds of citations because the computer will pull up any document within the data base where the term appears. Thus, it will be necessary to review the text of the retrieved documents to determine whether each regulation specifically regulates the substance in question or merely mentions it in passing.

The LEXIS® network can also search for federal regulations. LEXIS® is organized by libraries and files. For a general search, enter the CODES library and then choose either the CFR file for citations to the *Code of Federal Regulations* or the FEDREG file for citations to the *Federal Register*. Again, relevant citations may also appear. Both of these on-line data bases charge for the use of their service, including on-line time changes and charges for documents downloaded.

FLOW OF INFORMATION: The Regulatory Status module receives information from the Chemical Properties and Chemistry of Use & Process Description modules and transfers information to the Market Information, Control Technologies Assessment, Cost Analysis, and Risk, Competitiveness & Conservation Data Summary modules. Example information flows are shown in Figure 7-1.

FIGURE 7-1: REGULATORY STATUS MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: None cited.

PUBLISHED GUIDANCE: Table 7-1 lists published guidance and sources of regulatory data.

TABLE 7-1: PUBLISHED GUIDANCE AND DATA SOURCES

Reference	Type of Guidance
Chemical Regulations Reporter. Updated Periodically.	Looseleaf service for regulations regarding toxic chemicals.
Code of Federal Regulations Index. Updated Periodically.	Index to CFR providing guide to updates in Federal Register.
Environment Reporter. Updated Periodically.	Looseleaf service: text of federal and state laws and regulations.
Environmental Law Reporter. Updated Periodically.	Looseleaf service: news, statute texts.
Food and Drug Law Reporter. Updated Periodically.	Looseleaf service.
Index to the Code of Federal Regulations. Updated Periodically.	Index to CFR.
LEXIS® Network.	On-line data base of federal and state regulations and court opinions.
Occupational Safety & Health Reporter. Updated Periodically.	Looseleaf service.
Orloff, Neil, et. al. Updated Periodically. *Community Right-To-Know Handbook*.	Compliance guide to EPCRA.
Stever, Donald W. Updated Periodically. *Law of Chemical Regulation & Hazardous Waste*.	Comprehensive legal treatise.
Suspect Chemicals Sourcebook. Updated Periodically.	Regulatory analysis by chemical.
United States Code. Updated Periodically.	Official text of federal statutes.
United States Code Annotated. Updated Periodically.	Text of federal statutes with annotations.
*United States Code Servic*e. Updated Periodically.	Text of federal statutes with annotations.
U.S. Environmental Protection Agency. 1994b. *Federal Environmental Regulations Potentially Affecting the Commercial Printing Industry.*	Regulatory profile of the commercial printing industry.

TABLE 7-1: PUBLISHED GUIDANCE AND DATA SOURCES	
Reference	**Type of Guidance**
WESTLAW® Network.	On-line data base of federal and state regulations and court opinions.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: None cited.

PERFORMANCE ASSESSMENT

OVERVIEW: The Performance Assessment module measures how well a product or process performs to meet the functional requirements of the use cluster. Performance data are collected for both the baseline and the substitute processes and used as a basis for a comparative evaluation. The amount of effort required to perform a useful performance assessment may vary depending on the thoroughness of the study and the specific nature of the process under consideration. The performance assessment can involve an actual operating trial of the baseline and substitutes during a performance demonstration project or, if both the baseline and substitutes are well known and documented, the compiling of performance information from literature sources. This module provides assistance in developing methodologies for collecting comparative performance data and conducting a performance assessment. The focus of this module is on the design of an actual operating trial rather than compiling performance information from literature sources.

GOALS:

- Design accurate and reliable performance measures.
- Select and use protocols for measuring performance to achieve reproducible testing results, and to remove bias from the interpretation of results.
- Develop a supplier data sheet to facilitate collection of required data from vendors and suppliers.
- Develop an observer data sheet to ensure that consistent and complete data are collected during performance testing.
- Evaluate relative performance of substitutes.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Familiarity with the required characteristics of the baseline and substitutes and the factors affecting performance.
- Knowledge of measuring techniques and quality control testing procedures.
- Familiarity with the details of the operation of the baseline and substitutes under review.
- Ability to analyze variability of results using qualitative or statistical techniques.

Within a business or DfE project team, the people who might supply these skills include a process engineer, process operator, industrial engineer, or statistician. Vendors of equipment or chemicals used in the process may also be a good resource.

DEFINITION OF TERMS:

American Society for Testing and Materials (ASTM): An independent group that sets standard testing procedures for a variety of materials (e.g., environmental effects on galvanized metal surfaces, light bulb life testing).

Bias: Testing error caused by systematically favoring some outcomes over others.

Blind Testing: An experimental method in which the material or process under study is not known to an operator to avoid influence on performance/results testing.

Generic Formulation: A generic classification into which a group of similar chemicals or chemical formulations can be grouped, in order to be evaluated, protecting the proprietary nature of a formulation.

Objective Characteristics: Characteristics which when measured are independent of the measurer's influence (e.g., weight, size).

Reproducibility: The ability of a test to give consistent results.

Subjective Characteristics: Characteristics which when measured and assigned a value are influenced by the perceptions of the measurer (e.g., color, sound, taste).

Test Vehicle: A standardized unit that can be used as a basis for testing different processes (e.g., a standard circuit board design that can be used to test the ability of several different processes to plate a conductive material into the holes on the board).

Underwriters Laboratory (U.L.): An independent group that tests and certifies the safety of electrical appliances (e.g., toasters, electric hand drills, lamps).

Variability: The measured difference in certain characteristics of similar items (e.g., paint thickness, color consistency, part cleanliness).

APPROACH/METHODOLOGY: The following presents a summary of the technical approach or methodology for designing and conducting a performance demonstration. Further methodological details for Steps 4, 5, 6, 9, 12, and 13 are included in the Methodology Details section. In the procedure described below, the example of the use of a liquid cleaning agent applied to the surface of an ink-coated printing screen is used. Examples of an observer data sheet, and the testing methodology protocol for the screen printing industry are included in Appendix E.

Performance Protocol

Step 1: Obtain chemical properties data relevant to performance from the Chemical Properties module. Relevant properties for the example of a liquid cleaning agent to remove ink from a printing screen include vapor pressure (reflects tendency for evaporation), boiling point (indicates usable temperature range), and flashpoint (indicates fire ignition temperature level).

Step 2: Review the functional requirements of the use cluster listed in the Chemistry of Use & Process Description module. For the cited example, a minimal amount of residual ink on the screen after cleaning may be a specified requirement. A performance criteria may be that the screen must be cleaned until no visible ink residue remains on the screen surface.

Step 3: Identify relevant performance characteristics that could be qualitatively or quantitatively evaluated during the performance demonstration. These might include the ease of use (e.g., the physical effort required to clean the screens), the time required to accomplish the desired function (e.g., cleaning), the effectiveness of the substitute in achieving the function, or the effect of the substitute on the quality of the finished product (e.g., will use of the cleaner reduce the life of the screen).

Step 4: Identify variables which could significantly influence the results of the performance demonstration if not properly controlled. These might include process variables outside of the use cluster such as upstream process chemistry that must be adjusted to be compatible with the substitutes.

Step 5: Define methods of measuring each of the performance characteristics identified in Step 3. These methods, which may include laboratory testing as well as on-site analysis during the demonstration, should minimize the effect on results of the variables identified in Step 4. If applicable, the design and use of a test vehicle can help accomplish the above objectives.

Step 6: Define the parameters or conditions under which the demonstration of the baseline and substitutes will be performed. These parameters include when and where the demonstration will take place, along with who will observe the demonstration. Performance demonstration conditions should simulate real operating conditions as much as possible.

Step 7: Establish a procedure to quantitatively or qualitatively analyze each of the performance measures identified in Step 5. Analysis may be required on-site during the performance demonstration (e.g., how many cycles a screen will process before failure, testing to what extent a part is dried, etc.) or after the demonstration at a special test facility (e.g., the amount of light transmitted through a cleaned screen). Suppliers of chemicals and equipment should be consulted to ensure that the analysis methods are unbiased and do not favor a particular product or technology.

Step 8: Establish a performance scale for each of the performance measures to facilitate a comparative evaluation of the substitutes. The scale should consider both subjective and objective characteristics. (For example, visual inspection could be used to assign a high, medium or low level of cleanliness. A quantitative test, such as light transmission through cleaned screens, could be used to quantitatively measure the amount of residual ink left on a screen after cleaning.) Some objective characteristics can be evaluated using standard product specifications, such as military specifications.

Step 9: Develop a performance demonstration protocol based on the information developed in Steps 3 through 8.

Step 10: Review the Energy Impacts, Resource Conservation, and Cost Analysis modules to determine what data are required from the performance demonstration to complete those modules. Include in the protocol methods for collecting energy use, resources consumption and cost data, if required. The following data are typically gathered by the performance assessment:

- Energy Impact data: Collect data on energy consumed by motors, pumps, air fans, and other energy consuming process equipment. Data may include power rating, average duty, and average load.
- Resource Conservation data: Collect data on quantities of resources used in the process. Use direct measurement or examine historical records to determine rates of resources consumption (e.g., the amount of spent cleaner generated in the cleaning of screens).
- Cost Analysis data: Collect information on costs, such as operating and maintenance costs, process equipment costs, raw materials, utilities, as well as applicable indirect costs (e.g., waste management expenditures).

Step 11: If time and resources allow, perform test runs to evaluate the performance demonstration protocol for factors such as reproducibility. Performing trial runs will ensure that all important variables have been identified and controlled, and will highlight significant errors or impracticalities in the protocol.

Supplier and Observer Data Sheets

Step 12: Develop a supplier data sheet to collect consistent data from suppliers and vendors of the use cluster chemicals or technologies. One important purpose of the supplier data sheet is to collect information regarding the proprietary formulations of chemical products, which is necessary for the risk characterization component of a CTSA. The same data sheet should be disseminated to each of the vendors or suppliers of the chemicals or technologies being employed in the demonstration.

Step 13: Develop an observer data sheet to facilitate the collection and recording of consistent data at the time of the performance demonstrations. Because similar types of data must be collected, it may be helpful to use the questionnaire developed in the Workplace Practices & Source Release Assessment module as a basis for developing the observer data sheet. The data sheet should be completed by the observer for each test run at each performance demonstration site. In order to ensure an efficient on-site performance demonstration, it may be useful to distribute portions of the observer data sheet to participating test facilities prior to the demonstration. To minimize the variation in data recording, it is preferable to have the same observer complete the on-site portion of each data sheet.

Performance Results

Step 14: Conduct performance demonstrations for each of the alternatives using the performance protocol developed in Step 9. The demonstrations should be carried out in the presence of a neutral observer who can record the process conditions and complete the observer data sheet.

Step 15: If the test vehicle is to be shipped to an off-site laboratory for analysis, the observer should record the identification code of the test vehicle, package it according to a standard protocol and ship it to this laboratory. Only reporting the identification code to the off-site laboratory, and not the type of substitute demonstrated on the test vehicle, ensures blind testing by the off-site laboratory.

Step 16: Compare the performance results with the previously-defined performance characteristics to evaluate the comparative efficacy of the substitutes (e.g., substitute 1 failed to clean the screen effectively and was time-consuming, but substitute 2 cleaned the surface effectively and quickly). It is important to note that results from the performance demonstration may not be easily comparable, particularly if all key variables are not identified or able to be controlled.

Step 17: Transfer energy use, resource consumption and cost data to the appropriate modules. Transfer chemical formulation data to the Exposure Assessment module. Transfer performance assessment results from Step 14 to the Risk, Competitiveness & Conservation Data Summary module.

METHODOLOGY DETAILS: This section presents methodology details for completing Steps 4, 5, 6, 9, 12, and 13. If necessary, additional information on these and other steps can be found in the published guidance.

Details: Step 4, Identifying Variables

Given the screen cleaning example, the types of variables that could significantly influence the results of the performance demonstration, if not properly controlled, include the following:

- Environmental:
  - Ambient light levels needed for operator to judge screen cleanliness after cleaning operations.
  - Ambient air temperature can affect cleaning agent efficiency.
- Human Operator:
  - Different operators may handle and clean screens with different speeds and thoroughness.
- Process System:
  - Ink type and viscosity may affect cleaner action.
  - Design of screens may affect ease of cleaning along edges and in corners.

Details: Step 5, Measurement Methods and Test Vehicle Design

To reduce the potential for variation in the test results and thus improve the reproducibility of the test protocol, the performance demonstration should be designed to:

- Minimize the influence of secondary parameters (e.g., room temperature variation) to isolate the effect of the chemical/process on the performance results.
- Consider the different application methods or operational characteristics that may be required with one or more of the substitutes (e.g., spray application in lieu of hand wipe-on of screen cleaning agent).
- Use blind testing to minimize operator influence on the test outcome (e.g., different screen cleaning agents being evaluated could be provided to a worker in containers labeled with a number of different codes, several of which could be for the same cleaning agent).
- Minimize the potential for compounded effects caused by lack of control over several process variables. In this regard, it is important to identify all key variables so that all but a single performance measure can be controlled to the extent possible or practical.

A test vehicle can be developed and used to standardize the conditions and minimize the variables that can occur when testing several different processes. The use of a test vehicle is not always possible and should only be used when it is applicable and makes sense (e.g., a test vehicle may not be needed to test the efficacy of different chemical agents removing ink from a silkscreen). A test vehicle should not be used unless it can be designed to test all of the alternatives being considered. The design of the test vehicle should be done using input from manufacturers, DfE project team members, and suppliers of chemicals or technologies to ensure that the test vehicle performs its function without favoring a particular process being tested. The test vehicle should be designed to:

- Facilitate the testing of the performance characteristics listed in Step 3 for all of the alternatives being evaluated.
- Minimize the effect on results of the variables identified in Step 4 (e.g., use a screen with a consistent amount of stencil coverage and intricacy).

- Be broadly applicable to the range of products being evaluated (e.g., the variation of hole sizes on a circuit board test vehicle should be representative of the range of hole sizes used for a circuit board).

In addition, to minimize variation, test vehicles used at different demonstration sites should be manufactured under identical conditions at a single facility prior to shipment to the demonstration sites. This will minimize the variation in the test vehicles themselves.

Test vehicles that will be shipped to an off-site laboratory following processing at the demonstration site should be labeled with an identification code. The laboratory should use the same test methods to analyze all of the test vehicles, regardless of whether the test methods are qualitative or quantitative.

Standard ASTM or U.L. methods and military or other product specifications are available for some manufacturing processes and products and may be useful in designing the performance demonstration. Trade associations may have developed standard testing procedures for other processes or products. However, unique tests may need to be developed for many processes or products.

Details: Step 6, Selecting the Demonstration Sites

The performance demonstration may be carried out at any of the following facility types:
- Current operating facility.
- Operating facility that acts as a supplier test site.
- Supplier or trade association test site or demonstration facility.

Details: Step 9, Developing the Performance Demonstration Protocol

The performance demonstration protocol may include:
- A description of the test vehicle, if applicable, including specifications for manufacturing the test vehicle.
- The performance characteristics to be reported from the performance demonstrations.
- The processing or testing methodology (a step-by-step description of how the on-site performance demonstrations will be conducted, including any processing or testing requirements).
- The processing or testing parameters (the conditions under which the demonstration should be performed).
- The analysis procedures that will measure the performance characteristics.
- The performance scale that will be used to compare the results of the performance assessment.
- The number of times each test or analysis should be run.

Details: Step 12, Preparing a Supplier Data Sheet

The supplier data sheet can be used to collect the following types of data:

- Process operating parameters (e.g., compatibility with other process steps, product life, limitations, etc.).
- Material safety data sheets.
- Product formulation data.
- Equipment operating and maintenance procedures.
- Waste disposal requirements.
- Energy, cost, or resource data listed in Step 10 that are best supplied by vendors or suppliers (e.g., equipment power rating, equipment costs, maintenance costs, etc.).
- Any other data that are best supplied by the vendors or suppliers.

When proprietary chemical products are being used, the use of generic formulations may be necessary to obtain proprietary chemical formulation data from the supplier. A generic formulation allows the chemical formulation data to be evaluated in the process while protecting the proprietary nature of the chemical product. The generic formula is typically developed through the combined efforts of the suppliers and vendors of the chemical products along with members of the DfE project team, especially persons involved in the Exposure Assessment and Risk Characterization components of a CTSA (see Chapter 2: Preparing for a CTSA). An example method for preparing a generic formula is shown below.

(1) Group similar chemicals into categories. The categories can either be by chemical name or by similar chemical compound (e.g., alcohols).

(2) Provide a range of concentrations for the actual quantity of a chemical within the product formulation (e.g., 50-60 percent toluene).

(3) Exclude quantities of specific chemicals that are under a concentration agreed upon by the project team (e.g., one percent), such as surfactants or salts. Do not exclude potentially hazardous materials or chemicals that are regulated.

This method can be used to group formulations with specific chemicals in a range of concentrations (e.g., Product A: 20-40 percent methyl ethyl ketone, 15-25 percent butyl acetate, 10-20 percent methanol, 20-40 percent toluene), or to specify the actual concentrations of a chemical group (e.g., 40 percent propylene glycol series ethers, which can represent a number of different, but structurally similar, chemicals).

Details: Step 13, Developing an Observer Data Sheet

The observer data sheet should collect the following types of data:

- Personnel (e.g., facility contact, individuals performing demonstration, etc.).
- Demonstration conditions (e.g., ambient air temperature, air ventilation rate, humidity, etc.).

- Process description (e.g., equipment used, process steps, chemical product compositions, etc.).
- Type and identification code of test vehicle, if applicable.
- Observed operating procedures (e.g., time a panel is immersed in a chemical bath, process cycle time, amount of chemical used to clean a screen, etc.).
- Exposure data (e.g., chemical handling procedures, worker activities, personal protective equipment worn by workers, etc.).
- Process variables (e.g., temperature of chemical baths, worker operation inconsistencies).
- Energy, cost, and raw materials data listed in Step 10 (e.g., average energy load and duty, utility costs, water consumption rates, etc.).
- Any other data that are best collected by a neutral observer at the time of the performance demonstration.

In order to ensure an efficient on-site performance demonstration, it may be useful to distribute portions of the observer data sheet to participating demonstration sites prior to the demonstration. The partial observer data sheet should include:

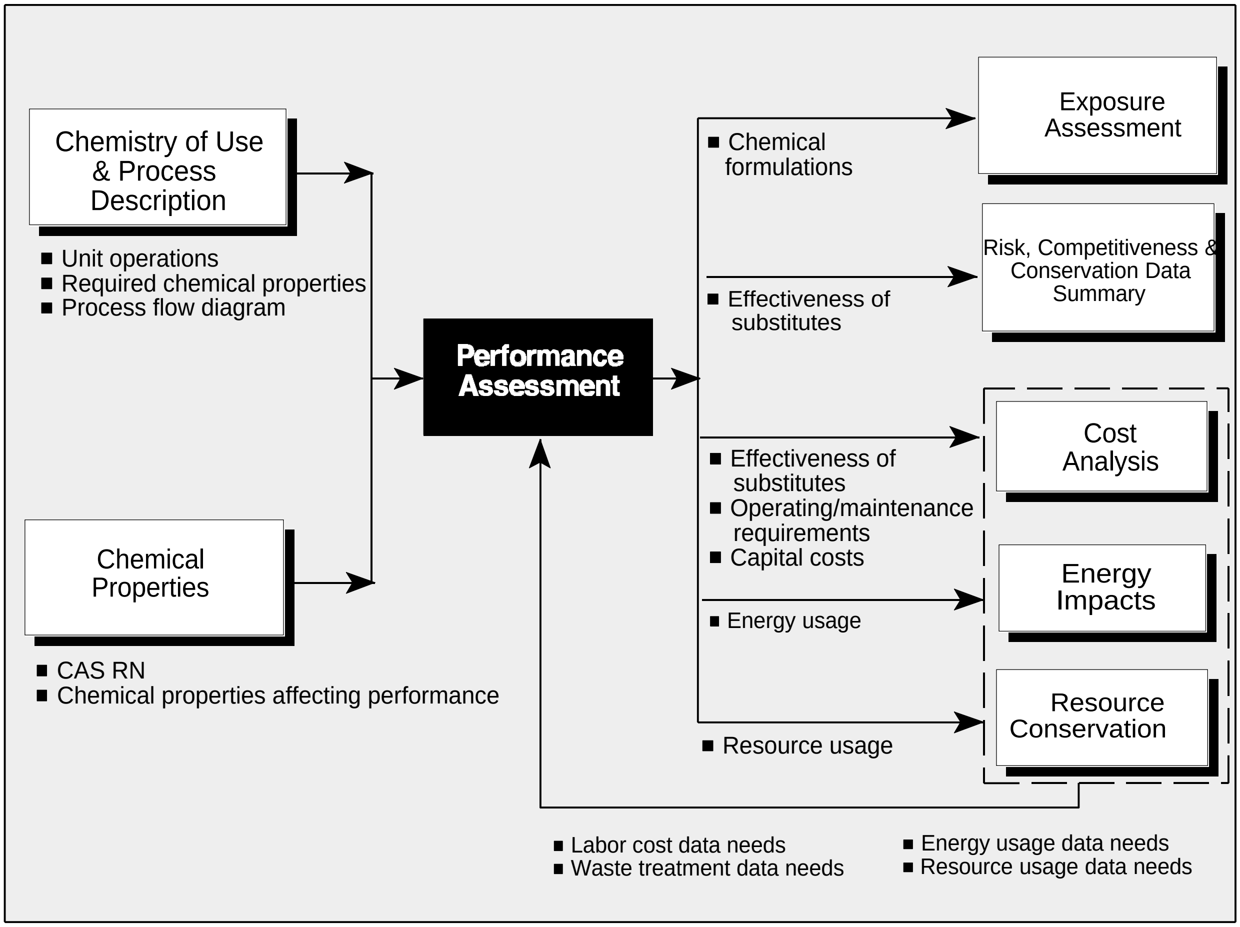
- A description of the process as it is performed at the specific test facility.
- Data that are difficult or time consuming to obtain (e.g., annual sludge volumes, data from company purchase records, equipment reliability data).
- Process history data (e.g., recent changes in equipment or operating practices that could effect the validity of data collected).
- Employee data (e.g., number of employees per shift, hours per shift).
- Any other data that can be collected by the facility that will help prepare observers for the demonstration or that are not readily available on-site.

By collecting and reviewing the facility completed portion of the observer data sheet prior to the facility test, the performance demonstration will be facilitated by allowing:

- Observers to become familiar with important process information prior to the performance demonstration.
- Data to be collected that are difficult or time consuming to obtain during a short on-site visit (e.g., annual chemical consumption, utility costs).
- The demonstration site to obtain the particular chemical products or technologies that are to be tested.

FLOW OF INFORMATION: The Performance Assessment module receives data requirements from the Energy Impacts, Resource Conservation, and Cost Analysis modules. It receives chemical and process information from the Chemistry of Use & Process Description and Chemical Properties modules. Performance data are transferred to the Exposure Assessment, Risk, Competitiveness & Conservation Data Summary, Cost Analysis, Energy Impacts, and Resource Conservation modules. Example information flows are shown in Figure 7-2.

-FIGURE 7-2: PERFORMANCE ASSESSMENT MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: None cited.

PUBLISHED GUIDANCE: Table 7-2 presents references for published guidance relevant to the design of a performance demonstration project.

TABLE 7-2: PUBLISHED GUIDANCE ON PERFORMANCE ASSESSMENT	
Reference	**Type of Guidance**
Kume, Hitoshi. 1987. *Statistical Methods for Quality Improvement.*	Methods for using statistics to measure performance, specifically quality, for the baseline and alternative chemicals or processes.
Montgomery, Douglas C. 1991. *Design and Analysis of Experiments*.	Information on designing non-biased experiments and statistical analysis of the results.

TABLE 7-2: PUBLISHED GUIDANCE ON PERFORMANCE ASSESSMENT	
Reference	**Type of Guidance**
Ray, Martyn S. 1988. *Engineering Experimentation: Ideas, Techniques, and Presentation*.	In-depth coverage of experimental techniques and equipment for measuring performance.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: None cited.

COST ANALYSIS

OVERVIEW: The Cost Analysis module identifies the costs associated with the baseline and alternatives, and calculates comparative costs between them. As a minimum, the cost analysis should identify and compare the direct and indirect costs of the baseline and the substitutes. If time and resources permit, data are also collected on future liability costs and less-tangible benefits that occur through the implementation of a substitute.

GOALS:

- Categorize and determine the costs that are incurred by the baseline and the substitutes.
- Identify less-tangible benefits that can result from the implementation of a substitute.
- Perform a comparative cost analysis of the baseline versus the substitutes.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Knowledge of current bookkeeping and accounting practices.
- Knowledge of, and ability to perform, cost analysis practices and procedures.
- Knowledge of product and customer buying base to identify less-tangible benefits.
- Knowledge of costs incurred by the baseline and substitutes and other aspects of direct cost allocation.

Within a business or a DfE project team, the people who might supply these skills include a purchasing agent, marketing specialist, floor manager, an accountant, or an economist. Vendors of process equipment or chemicals may also be a good resource.

DEFINITION OF TERMS:

Cost Allocation: The method of assigning costs that have been incurred to the products and processes that generated the costs.

Direct Costs: Costs that are readily assignable to a specific process or product. These costs include capital expenditures, and operating and maintenance costs (e.g., labor, materials, utilities, etc.).

Discounting: Economic analysis procedure by which monetary valuations of benefits and/or costs occurring at different times are converted into present values which can be directly compared to one another.

Expanded Time Horizon: The concept of evaluating an economic analysis over an extended period of time (e.g., 10-20 years) as opposed to the traditional 3-5 year period. This concept is important to identifying the pollution prevention benefits of a substitute, because many of the liability costs and less-tangible benefits occur over a longer period of time.

Indirect Costs: Costs that are incurred by the operation of a business but not typically allocated to a specific process or product. Administrative costs, regulatory compliance costs, and workman's compensation costs are all examples of indirect costs.

Internal Rate of Return (IRR): The discount rate at which the net savings or net present value of an investment are equal to zero. An investment is economically justifiable when the IRR equals or exceeds a company's desired rate of return.

Less-Tangible Benefits: Benefits that may occur but cannot be readily quantified (e.g., reduced health maintenance costs due to a safer work environment, or increased product sales due to better product performance, etc.).

Liability Costs: Difficult to quantify costs incurred as a consequence of uncertain future liability for clean-up of hazardous substance releases or for liabilities from personal injury claims stemming from environmental releases or product use.

Net Present Value (NPV): The present value of future cash flows of an investment less the current cost of the investment.

Present Value (PV): A concept which specifically recognizes the time value of money, i.e., the fact that $1 received today is not the same as $1 received in ten years. Even if there is no inflation, $1 received today can be invested at a positive interest rate (say 5 percent), and can yield $1.63 in ten years. Present value refers to the value in today's terms of a sum of money received in the future. In the example above, the PV of $1.63 received in ten years is $1, i.e., $1 received today is the same as $1.63 ten years in the future. Alternately, the PV of $1 received in ten years is $0.61. The rate at which future receipts are converted into PV terms is called the discount rate (analogous to the interest rate given above). The formulation for calculating PV is given in the Methodology Details section.

APPROACH/METHODOLOGY: The following presents a summary of the approach or methodology for performing a cost analysis. Further methodology details for Steps 1, 2, 4, 5, 6, 7, and 8 follow this section.

Step 1: Determine data requirements for the cost analysis and provide them to the Performance Assessment module so that cost data can be collected during the performance demonstration project. Data should be collected on a per unit production basis, or some other basis that allows a comparative evaluation of the trade-off issues (e.g., energy impacts, resource conservation, risk, etc.).

Step 2: Obtain the data identified in Step 1 from the Performance Assessment module. Obtain additional cost-related data from the Energy Impacts, Resource Conservation, Control Technologies Assessment, Regulatory Status, Process Safety, Market Information and International Information modules. Energy, chemical, and resource consumption data are usually collected in the Performance Assessment module and compiled in the Energy Impacts and Resource Conservation modules, respectively.

Step 3: Review the Workplace Practices & Source Release Assessment module to determine if resource consumption rates, waste generation rates, and worker activities reported for the baseline and alternatives are consistent with the data obtained in Step 2. If the data are not consistent, it may be necessary to have knowledgeable industry personnel review and resolve any inconsistencies.

Note: To ensure that the cost analyses for alternatives are comparable, data from the Workplace Practices & Source Release Assessment module should be used in actual cost calculations only if the data are available for all of the alternatives being evaluated. The Workplace Practices & Source Release Assessment module may not contain information on new or novel alternatives that are not widely used.

Step 4: Calculate the direct costs associated with the operation of the baseline and the alternatives using the data gathered in Step 2 and checked in Step 3. Direct costs include capital expenditures, operating costs, and maintenance costs. Waste management costs are also examples of direct costs, but many businesses allocate these costs to overhead.

Step 5: Calculate indirect costs for the baseline and alternatives. The data gathered in Step 2 will determine many indirect costs, while other indirect costs can be estimated from other sources. Indirect costs are considered hidden costs because they are often allocated to overhead rather than their source, or are omitted altogether from a cost analysis.

Step 6: If time and resources permit, identify future liability costs associated with the operation of the baseline and alternatives. In most instances, the estimation of future liability cost is subject to a high degree of uncertainty. Therefore, the need to quantify the future liability may be less important than recognizing that the future liability exists.

Step 7: If time and resources permit, identify any less-tangible benefits that could result from the implementation of a substitute. The benefits of a cleaner product, process, or technology can be substantial and should not be overlooked when performing a cost analysis.

Step 8: Perform cost analyses of the baseline and alternatives using the cost data collected in Steps 3 through 6. The cost analyses should be performed using a traditional cost accounting method or an alternative cost method. An example of a cost analysis can be found in Appendix G.

Step 9: Provide the results of the cost analysis to the Risk, Competitiveness & Conservation Data Summary module.

METHODOLOGY DETAILS: This section presents the methodology details for completing Steps 1, 2, 4, 5, 6, 7, and 8. If necessary, additional information on conducting a cost analysis can be found in the published guidance. Appendix G contains the cost analysis from the Lithography CTSA.

Details: Step 1, Collecting Cost Data

The following information may be needed for the cost analysis:
- Labor requirements (e.g., cycle time to produce a product unit, ease of use, number of employees to operate process, maintenance labor costs).
- Waste generation rates (e.g., waste water discharges, solid wastes generated).

Equipment and/or chemical costs may also be collected from suppliers during the performance demonstration if this information was not compiled in the Market Information (cost of U.S. supplied equipment and /or chemicals) and International Information modules (cost of foreign supplied equipment and/or chemicals).

If an actual performance demonstration is not planned during the CTSA (e.g., if performance data are being collected from existing sources instead of tests performed as part of the CTSA), cost estimates can be obtained using standard cost estimating techniques and/or cost estimation software combined with data from equipment vendors or other sources.

Details: Step 2, Obtaining Cost-Related Data From Other Modules

Cost-related data are obtained from the following modules:
- Chemical and other resource consumption rates (e.g., water, raw stock, etc.) should be obtained from the Resource Conservation module.
- Energy consumption rates should be obtained from the Energy Impacts module.
- Control technology equipment requirements should be obtained from the Control Technologies Assessment module. Costs of controls can be estimated using information contained in regulatory background documents or obtained from vendors and suppliers.

- Regulations requiring specific disposal methods for process wastes (e.g., processes that generate listed hazardous wastes) should be obtained from the Regulatory Status module. Costs of these disposal methods can be estimated using information contained in regulatory background documents or obtained from suppliers or disposal companies.
- OSHA requirements for special conditions or equipment needed to ensure process safety should be obtained from the Process Safety module. Costs of these requirements can be estimated using information contained in regulatory background documents or obtained from vendors and suppliers.
- Chemical and process equipment costs should be obtained from the Market Information module (U.S. supplied), International Information module (foreign supplied), and/or from supplier information provided to the performance demonstration, as noted in Step 1.

Details: Step 4, Calculating Direct Costs

Direct costs include the following:
- Capital expenditures (e.g., process equipment, control technologies, installation, project engineering, etc.).
- Operating costs (e.g., direct labor, raw materials, utilities, quality assurance testing, etc.).
- Maintenance costs (e.g., equipment cleaning and repair).

The details for Step 8, below, discuss how to calculate present value for costs that are incurred over time.

Details: Step 5, Calculating Indirect Costs

Indirect costs are hidden costs obscured in a cost category of overhead, or omitted completely. They include:
- Supervision and administrative costs.
- Regulatory compliance costs (e.g., permitting, monitoring, manifesting, employee training, etc.).
- Waste management expenditures (e.g., on-site pollution control costs, waste disposal charges, etc.).
- Insurance, rent, taxes, etc.

Not all indirect costs will be relevant to the cost analysis. For example, costs that are constant for both the baseline and the alternative may be excluded from the analysis.

The details for Step 8, below, discuss how to calculate present value for costs that are incurred over time. The following is a discussion of two methods for determining indirect costs.

<u>Traditional Estimation Method</u>: This method determines and allocates indirect costs to a process or product based on some measurable parameter (e.g., labor hours, capital investment). For example, maintenance costs for a piece of equipment can be estimated based on the capital cost of that equipment, where maintenance costs equal some function of capital cost. This method is the most common accounting method used throughout industry.

Activity-Based Costing (ABC) Method: This method of accounting allocates indirect costs to products or processes, based on how the products or processes actually incur these costs. This allocation is done using a series of cost drivers that are keyed to the activities required to produce the products. For example, the operating costs of an ion exchange bed used to treat liquid waste streams from various sources would be divided and attributed directly to each individual source in proportion to the percentage of its overall use.

Traditional Estimation Method vs. ABC Method: Traditional estimation methods are less complicated and time consuming than ABC methods. Little or no change to the current financial accounting methods are typically required. In contrast, ABC provides for a more accurate picture of costs by evaluating the actual activities of each process. ABC allows managers to cite specific problem areas in a process that would otherwise go undetected. As a result, the direct benefits of a substitute that addresses these problems are more easily identified. ABC, however, is time consuming because of the considerable effort needed to track each activity in the process. Therefore, additional administrative costs may be incurred to set up an ABC system, but the opportunities for cost savings identified by the ABC method probably would more than offset this cost.

In many cases it may be difficult to determine all indirect costs for substitutes that are not in widespread use. In these cases, ABC methods can be supplemented with the traditional estimation methods for the unavailable data. For example, determining if a waste stream is hazardous as defined by RCRA may not be possible until an alternative is fully implemented and the nature of the waste realized. Assumptions that are made about the applicability of environmental regulations and the associated costs should be explicitly stated. The Regulatory Status module helps to identify potential compliance issues.

Details: Step 6, Identifying Liability Costs

Liability costs include the following:

- Penalties and fines (e.g., penalties stemming from non-compliance with current or future environmental regulations).
- Personal injury (e.g., liability claims stemming from environmental releases of chemicals or consumer use of a product).
- Property damage (e.g., liability claims stemming from environmental releases from disposal sites).
- Clean-up costs (e.g., Superfund mandated corrective action).
- Natural resource damages (e.g., Superfund mandated damages).

Details: Step 7, Identifying Less-Tangible Benefits

Less-tangible benefits include:

- Increased sales due to improved product quality, enhanced public image, consumer trust in green products, or other effects.
- Reduced health maintenance costs due to a safer work environment.

- Improved worker productivity due to cleaner working conditions (e.g., fewer volatile solvents in cleaning area, less dizziness).
- Increased worker productivity due to improved employee relations.

Details: Step 8, Conducting a Cost Analysis

When conducting the cost analysis, the project team should select long-term financial indicators that account for the time value of money and all cash flows from implementing the baseline or a substitute. Two commonly used financial indicators include NPV and IRR. Formulas for calculating PV and NPV are discussed below. Discussions on IRR and other financial indicators may be found in economic analysis textbooks.

Calculating Present Value and Net Present Value

For a one-time cost or benefit, PV is given by the formula:

$$PV = \frac{CF_t}{(1 + r)^t}$$

where:

CF_t represents the value of a one-time cash flow, CF, received in year t, and r represents the discount rate

For a series of benefits to be received over several years, present value is given by the formula:

$$PV = \sum_{I=1}^{T} \frac{CF_t}{(1 + r)^t}$$

where:

$\sum$ represents the summation of benefits in the time period which ranges from year 1 to year T

NPV is given by the formula:

$$NPV = PV - I$$

where:

I is the initial outlay or investment cost

Costing Methods

Traditional costing methods or Total Cost Assessment (TCA) can be used to perform the cost analysis. Both methods allow for the calculation of a net cash flow, IRR, or NPV. The methods differ in which costs are calculated and how costs are allocated. The following is a discussion of the advantages and disadvantages of different costing methods.

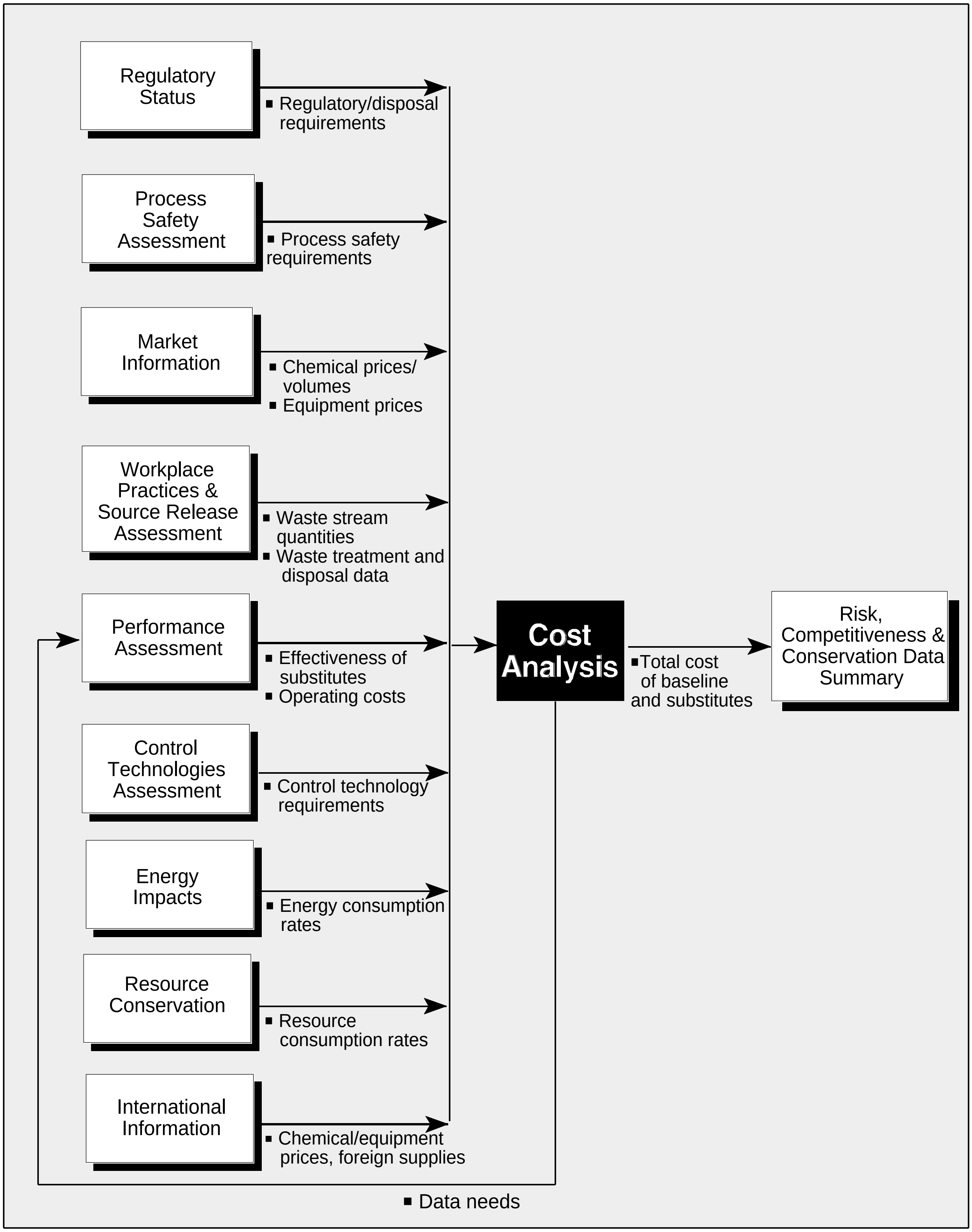
<u>Traditional Costing Method</u>: This method of cost analysis typically ignores future liability costs and considers all indirect costs as overhead or omits them altogether. These overhead costs, if considered, are randomly allocated to a process or product based on some measurable, yet arbitrary parameter (e.g., labor hours, capital equipment costs). This method is the most common accounting method used throughout industry.

<u>Total Cost Assessment (TCA)</u>: This accounting method attempts to analyze all of the costs and liabilities, along with the potential benefits, over an expanded time horizon to gain a more comprehensive profile and comparison of alternatives.

<u>Traditional Costing Methods vs. TCA</u>: Traditional cost accounting is the easiest and least complicated of the cost analysis methods. The need to quantify or estimate difficult-to-determine indirect costs and future liabilities is minimized or eliminated. The potential impacts the substitutes have on indirect costs are considered qualitatively. In contrast, TCA is an important improvement over traditional costing methods. By using an expanded time horizon, including indirect costs, and quantifying less-tangible costs, TCA is a more representative cost accounting method. One limitation of the TCA method is that there are no commonly accepted methods of quantifying some future liability costs, and little or no agreement on how less-tangible benefits should be valued. Both methods require little or no changes to the current financial/managerial accounting methods typically used in industry.

FLOW OF INFORMATION: This module provides data needs to the Performance Assessment module, receives information from the Regulatory Status, Process Safety Assessment, Market Information, Workplace Practices & Source Release Assessment, Performance Assessment, Control Technologies Assessment, Energy Impacts, Resource Conservation, and International Information modules, and transfers information to the Risk, Competitiveness & Conservation Data Summary module. Example information flows are shown in Figure 7-3.

FIGURE 7-3: COST ANALYSIS MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: Table 7-3 lists references for computer models to assist with a cost analysis. Tellus Institute, with funding from the EPA DfE Program and the National Institute for Standards and Technology, is developing environmental cost accounting and capital budgeting software designed to help small and medium-sized businesses cost pollution prevention projects. Currently, software is available for screen printers; software packages for lithographers, flexographers, the metal fabrication and finishing industries, and printed wiring board manufacturers are under development.

TABLE 7-3: ANALYTICAL MODELS FOR COST ANALYSIS

Reference	Type of Model
Tellus Institute. 1993. *P2/Finance: Version 2.0*.	Financial analysis and cost evaluation software for the personal computer.
Tellus Institute. 1995. *P2/Finance for Screen Printers: Version 1.0*.	Financial analysis and cost evaluation software for the personal computer.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

PUBLISHED GUIDANCE: Table 7-4 presents references for published guidance on cost analysis.

TABLE 7-4: PUBLISHED GUIDANCE ON COST ANALYSIS

Reference	Type of Guidance
Brimson, James A. 1991. *Activity Accounting - An Activity-Based Costing Approach.*	Describes activity based costing method.
Brown, Lisa, Ed. 1992. *Facility Pollution Prevention Guide.*	Provides overview of total cost assessment issues and method.
Collins, Frank, Ed. 1991. *Implementing Activity Based Costing.*	Describes activity based costing method.
Northeast Waste Management Officials Association. UNDATED. *Costing and Financial Analysis of Pollution Prevention Investments.*	Provides methods of financial analysis.
Tellus Institute. 1991a. *Alternative Approaches to the Financial Evaluation of Pollution Prevention Investments.*	Describes and compares various costing methods.
Tellus Institute. 1991b. *Total Cost Assessment: Accelerating Industrial Pollution Prevention Through Innovative Project Financial Analysis, with Applications to the Pulp and Paper Industry.*	Describes total cost assessment methods.

TABLE 7-4: PUBLISHED GUIDANCE ON COST ANALYSIS	
Reference	**Type of Guidance**
U.S. Environmental Protection Agency. 1989c. *Pollution Prevention Benefits Manual: Phase II*.	Formulas for incorporating future liabilities into a cost analysis.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: None cited.